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Process-Based Information Systems: Technological Infrastructure and Development Issues

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Abstract

Now, more than ever, organizations need information systems which may be quickly developed, rapidly reconfigured, and easily maintained. In this paper, we describe a specific IT infrastructure, inspired in the concept of business process, and mainly based on the functionalities provided by collaborative and workflow technologies, which might fulfill those needs. This infrastructure facilitates the construction of distributed IT solutions, in a component-based fashion. We argue that these solutions (Process-Based Information Systems - PBIS), allows organizations to quickly respond to changing business requirements and, moreover, simplifies the integration of new IT artefacts. In the context of PBIS, we propose a set of development requirements.

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Keywords: Process-Based Information Systems (PBIS); Workflow Technology; Collaborative Applications; Component-based Architectures.

1. Introduction

The turbulent and increasingly competitive markets in which modern organizations have to operate and do business requires from their computerized information systems the ability of being quickly developed, rapidly reconfigured, and easily maintained [1]. These qualities are of extreme importance as IT solutions play a critical role in the competitiveness of organizations. In fact, everyone agrees that, in the global and knowledge intensive society

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we live in, organizations compete, more and more, in terms of their agility in reacting timely and adequately to the market pressures and opportunities [2]. Obviously, the computerized information systems that support the everyday operations and management of organizations play a critical role in this environment.

In addition to these demanding market conditions, organizations also have to deal with an increasingly complex IT environment, where new technologies are continually appearing on the landscape. Of course, it is necessary that organizations make a creative use of the new technological possibilities in their information systems development efforts, so that they can remain competitive. In the technological domain, due to the widespread use of the personal computer and the so called commodity hardware, associated to the huge advances in the data communications field, the monolithic data processing solutions of the past, based on expensive computer platforms, are being quickly replaced by sets of powerful and cheap computers, associated with a myriad of computer peripherals, interconnected by data networks, thus originating highly distributed solutions [1], [3].

As a consequence, technological complexity, distribution and rapidly changing requirements are the fundamental keywords in the Information Systems Development (ISD) arena of the present days. Therefore, additionally to using suitable ISD methodologies, organizations have to create the technological infrastructure that will allow them to develop and maintain, timely and effectively, their information systems, making use of all the technological possibilities that arise [1].

In this paper we describe a specific IT infrastructure, inspired on the concept of business process, and largely built on the functionalities provided by collaborative/workflow technologies, which will facilitate the development of distributed IT solutions in a component-based fashion. Furthermore, we argue that this specific kind of IT solution allows organizations to evolve quickly in face of changing business requirements, and facilitates the integration of the existing and new technologies, simplifying the overall development and maintenance effort of information systems. In the following, we describe a high-level set of development requirements associated to our specific proposal. Finally, we make some comments and conclude.

2. Collaborative and workflow technologies

As a result of the remarkable developments in the hardware and data communications fields, a set of technologies, globally known as collaborative technologies, has emerged. These technologies are primarily intended to support the communication and collaboration needs of people working together [4]. Electronic mail, videoconference, team rooms, group editors, discussion groups and workflow systems are just some examples of collaborative technologies.

Different collaborative technologies have distinct characteristics regarding the time and space dimensions. A commonly used classification for the various collaborative technologies is Johansen's Time/Space Matrix [5]. This classification tries to distinguish among the different collaborative technologies, classifying them in a synchronous/asynchronous and centralized/distributed framework.

Although workflow systems are normally considered as a kind of collaborative system, there is a subtle but very important difference between workflow and the other types of collaborative technologies. While all of them intend to facilitate the communication and collaboration among a group of people, the workflow systems aim, more specifically, to coordinate their interactions according to a particular business/organizational process [6].

The Workflow Management Coalition (WfMC), a non-profit international body created for the development and promotion of workflow standards, defines workflow as "*The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules*" [7]. Therefore, the notion of process automation is central to workflow technology.

A widely accepted classification of workflow products distinguishes among four categories: ad hoc, collaborative, administrative and production workflow [8]. The differences among them consist, very broadly speaking, in the more or less rigidity of the process enactment. Thus, in one extreme, we find production workflow, which aims to support the enactment of completely pre-defined business processes, executing them in a very rigid and strict way. In the other extreme, we find collaborative workflow, where the focus is not so much the process per si, but the sharing of information among the people (actors) involved in the process [9].

Business Process Management Systems (BPMS) are the modern software systems that implement the workflow concept by managing the execution of business processes, according to their specification models. During the

execution of a business process, the BPMS delivers work to actors (humans or machines) according to the correspondent process model and the execution context of each particular process instance. In doing so, the workflow engine of the BPMS invokes the suitable available applications with the corresponding data involved, thus creating the adequate execution context for each process activity [10]. The success of the business process paradigm has led to the development of many commercial BPMS. These include Oracle Business Process Management Suite, TIBCO ActiveMatrix, AuraPortal, Bizagi BPM Suite, and so on. In the open source community BPMS products like jBPM, Bonita BPM or Intalio are also very successful.

3. The process-based information system concept

In the past there were several attempts to develop the so-called enterprise-wide information systems. These are large systems, almost inevitably distributed, which try to create a cohesive whole from dispersed components. The first serious systems integration efforts began with the advent of Data Base Management Systems (DBMS). Since the construction of a centralized repository containing all the organizational data was not always possible or even feasible, different solutions were engineered, such as distributed databases, in which the data was physically dispersed by several databases, but could be seen by the applications as a unique, logically integrated, repository.

This kind of systems integration may be called *integration-via-data* (i.e., the systems are interconnected at the data level). Other distributed solutions involve Transaction Processing Monitors to interconnect dispersed systems in the execution of distributed transactions and distributed objects interconnected by middleware technology such as web services [11]. Owing to the facilities provided by the collaborative technologies and, in particular workflow technology, a new possibility of systems integration has emerged, much more promising than integration via data: the *integration-via-processes*.

In the heart of the integration-via-processes approach are the BPMS. In fact, a BPMS may be regarded as a very sophisticated form of middleware which more than allowing a passive interconnection between different systems, allows their *active interconnection*, making them cooperate explicitly in the execution of a business/organizational process. Thus, a BPMS may be seen as a coordination level which, if placed over the conventional and collaboration systems of the organization, is able to control their cooperation [12]. To this global solution we call *Process-Based Information System* (PBIS).

In the PBIS context we make a distinction between *conventional systems*, *collaboration systems* and *coordination systems* [12]. By conventional systems we mean all sorts of computer information systems used to support individual work, such as Transaction Support Systems (TPS), Data Processing Systems (DPS), as well as Management Information Systems (MIS), Decision Support Systems (DSS), Executive Information Systems (EIS), expert systems, personal productivity tools (word processors, spreadsheets, personal databases, etc.) and, in a generic way, all the legacy information systems still in operation in organizations.

By collaboration systems we mean all sorts of computational systems used to support people working together in groups, such as videoconference systems, electronic meeting systems, electronic mail systems, etc. Conventional systems and collaboration systems are used in organizations to support people doing work in an individual or group setting, respectively. In the PBIS context we classify these two kinds of system as *operation level*.

By coordination systems we mean a special kind of systems intended to control the way work flows among participants in a business process. In this group, the workflow engines of BPMS are a notorious example. In the PBIS context these systems are used to implement the *coordination level*.

BPMS, besides supporting directly the process concept, have a fundamental and distinct characteristic. They allow the explicit separation between the process logic and the applications that implement the activities in the process model. So, just by using this technology we are able to separate and manipulate, in an independent way, the organizational/business processes (coordination level), and the applications used to do the work (operation level). Concerning the PBIS operation level, we distinguish among three types of work activities [1],[12]:

- *Automatic activities*, executed entirely by a machine actor, without human intervention;
- *Individual activities*, handled by a human actor, eventually supported by some kind of S/W artefact;
- *Group activities*, which require the collaboration of at least two human actors, in a synchronous or asynchronous way, being in the same space or geographically distributed.

The first two types of activities are good candidates to be supported by "conventional" IT. The last one (group activities) implies the use of suitable collaborative tools adequate to the needs of the specific situation.

By integrating coordination systems with conventional and collaborative systems, PBIS stand as a powerful technological framework with potential to unify all the computational resources of an organization into a single global infrastructure, under the concept of business process (see Fig. 1).

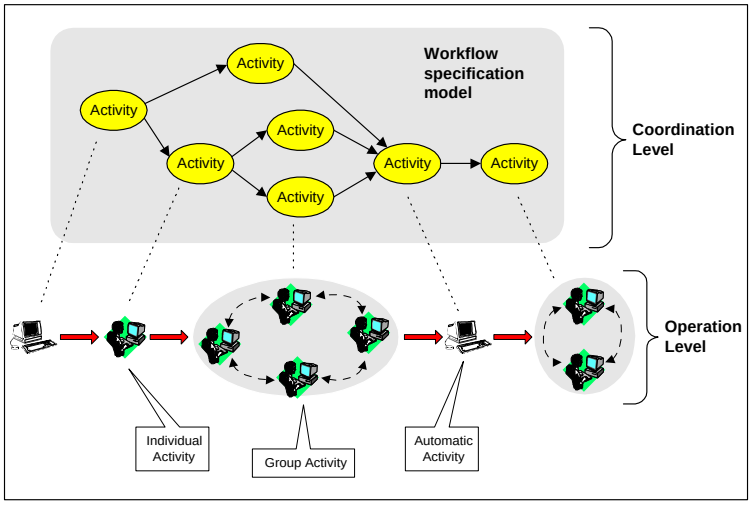

Fig. 1 - The PBIS Framework

4. PBIS development as a (macro-)component-based approach

BPMS are simultaneously a coordination technology (it allows to control the execution of other applications) and an integration technology (it behaves like a middleware technology that interconnects different systems).

In a very simplistic way, we can identify two levels of component-based development: (1) the common component-based software development, largely based on the OO paradigm, used to develop software applications and (2) the higher level component-based systems development where complete, discrete and autonomous blocks of functionality (e.g. IT applications) are glued together in a specific way in order to build a larger system. In the PBIS context, we call those complete IT applications *macro-components*. The interconnection of those macro-components is conceptually based on the notion of business process and implemented via BPMS.

This approach promotes the incremental development of computer based information systems in a component-based fashion, trying to maximize the reuse of large software building blocks (IT applications). In fact, a PBIS is developed, piece by piece, in a very modular way, by adding successive process models to the coordination level, and reusing or, if not available, developing/buying new IT applications in the operation level. As time goes by, as new business processes are added to the PBIS, the level of applications' reuse will increase and, in the limit, the coordination level will be a fair representation of the corporate process model, where "all" the business processes of an organization might be represented [12].

Due to the component-based style of the PBIS framework, it is easier to deliver quick solutions, which are easily maintainable, thus increasing the productivity of the information systems development professionals. On the one hand, the PBIS approach promotes the concurrent development of the different components of the system, which certainly very much contributes to a faster development of the whole system. On the other hand, the clear separation between the coordination level and the operation level, which is a distinct characteristic of the PBIS framework, makes it possible to change or redefine the organizational processes without affecting the existing applications, and vice-versa. Therefore, the PBIS approach results in easily maintainable and highly configurable and flexible systems.

5. PBIS Development

What organizations need today, to succeed in the challenging conditions of the new markets, is an integrated approach to Information Systems Development (ISD). One which makes full use of all the IT and computational resources available, both the conventional and the emerging ones, under the concept of business process.

Bearing those issues in mind, we can depict a division of a PBIS Development project in a series of smaller and mostly independent subprojects: a workflow development project, corresponding to the coordination level; and, depending on the types of activities that appear in the operation level, several collaborative and/or conventional application development projects. A final project corresponds to a systems integration phase which, making use of the facilities made available by BPMS, integrates the different subsystems into a global solution – the PBIS (Fig. 2).

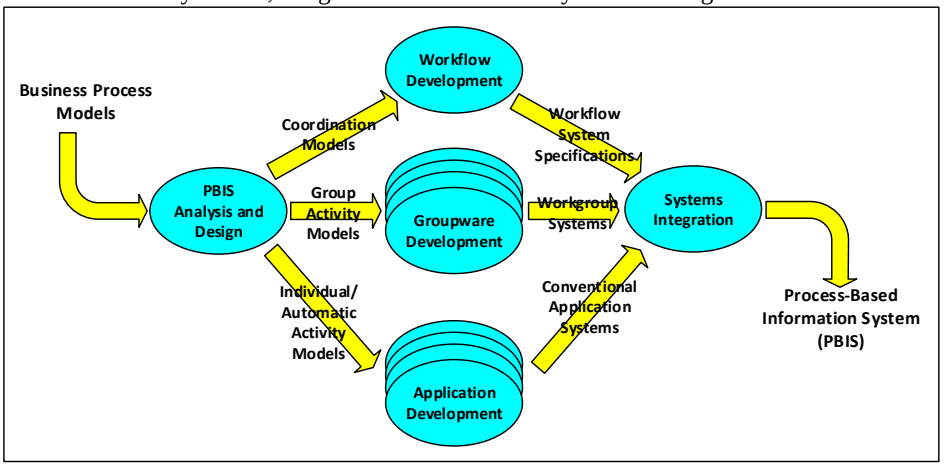

Fig. 2 - The PBIS Development approach

The transformation of business process models into information systems specifications, adequate to the development of computer artefacts, is a complex process that requires a strong involvement and commitment of all stakeholders – the business agents and the IS/IT experts. As practice has shown, this is an essential prerequisite for the latter acceptance of the developed systems. In the PBIS approach, excluding the systems integration, which is a rather technical phase, business agents need to be present at all phases.

The first PBIS step (*PBIS Analysis and Design*) transforms a business process model into a set of models adequate to the development of the various PBIS components.

The individual/automatic activity models represent the requirements specifications of the applications needed to automate work procedures or to support the work of individuals, respectively. Those models are used as a basis to develop the corresponding IT applications, reuse applications already existent in the organization, or select and acquire commercially available software packages (usually known as COTS – *Common Of The Shelf* packages)

Regarding the modelling language used to express those specifications, we claim that UML (Unified Modelling Language) is a convenient requirements specification language. The principal reason is that, today, UML is viewed as the standard modelling language for software development. Another reason is that the UML set of models are methodology-neutral and so, they may be used subsequently in any methodology context, allowing organizations to choose freely their software development approaches [13].

The group activity models represent the requirements specifications of the workgroup systems intended to support group activities. It is important to note that groupware systems are general-purpose systems, which can be employed in a multitude of situations. The contribution of PBIS Development at this level consists in the appropriate specification of the collaborative facilities needed for each work situation. These specifications will be subsequently used to select the suitable collaborative tools.

In the case of a group activity requiring the synchronous collaboration among several human actors (e.g., a meeting between two or more people to make a joint decision) it is necessary to find a moment in which the required

participants (each one with his/her own agenda) can meet together, in geographically co-located or distributed fashion [14]. Although the internals of the group activity are not under control of the coordination system, the start and end conditions are its responsibility.

Concerning the coordination models, these are used to develop the workflow specifications. Once again, we recommend the use of a standard modelling language for specifying coordination models, independent of any specific BPMS. In this regard, the BPMN (Business Process Model and Notation) stands as the suitable option [15].

6. Conclusions

The PBIS approach promotes the incremental development of Information Systems, in which the whole solution is developed piece by piece, in a very modular way, by adding successive workflow models to the coordination level, and reusing or, if not available, developing/acquiring new applications and groupware facilities in the operation level.

Today, more than ever, organizations need to use rapid approaches to ISD. Due to the rapid pace at which things change today, to maintain the information systems continuously aligned with the needs of the business, ISD methodologies have to deliver rapid solutions. Regarding this subject, the PBIS approach, because of its component-based style, may deliver quick and suitable solutions, which are easily maintainable. On the one hand, the PBIS promotes the concurrent development of the different components of the system, which certainly very much contributes to a faster development of the whole system. On the other hand, the clear separation between the coordination level and the operation level, which is a distinct characteristic of the PBIS approach, makes it possible to change or redefine the organizational processes without affecting the existing applications, and vice-versa. Thus, PBIS stand easily maintainable and highly configurable.

This approach also considerably facilitates the management of large ISD projects. Indeed, by dividing a large system into a set of subsystems, which may be independently developed or acquired, an otherwise complex project will result in a series of small (sub)projects, much more easily managed. In fact, the activities included in the process models are treated as independent components (“black boxes”), specified and developed/acquired independently from each other. Obviously, this will greatly simplify the management of ISD projects.

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